PATENT SPECIFICATION

466,985

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COMPLETE SPECIFICATION

Tank for the Subwater Storage of a Liquid Specifically Lighter than Water

I, SERVAN GEORGES CANTACUZENE, of Nr. 207, Rue de l'Université, Paris (Seine Department), France, of Roumanian nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to a tank for the sub-water storage of volatile liquids.

According to the invention the tank for the sub-water storage of liquids lighter than water is characterised by the feature that it comprises a container held by a ballast, mooring line or other suitable means at the bottom or at any level of the water, said container comprising means for the admission or discharge of the surrounding water to or from its lower part and at its upper part means for the admission or discharge of the liquid lighter than water.

Tanks are known in which the volatile liquid is supported by a denser liquid for example water; similarly tanks of this kind are known in which the water creates a pressure greater than that due to the vapour pressure of the volatile liquid.

Tanks of the same kind are also known which are partly immersed in water and which are constituted by a kind of bell without a base. These tanks emerge from the water and are visible; further they are secured so as to remain at the bottom of the water, since they rest on supports buried in the ground.

Tanks of this kind are also known which are intended to be constructed in the water at the bottom of a river or ditch and which are covered with water in order to protect their contents against fire. These tanks are constructed of concrete and are not removable. They are intended to be covered with a small layer of water and certain of their parts such as piping, walls, etc. are located at the surface and are therefore visible. The upper parts of these tanks are in communication with the atmosphere in order to prevent variations in pressure.

Finally tanks of this kind are known which are intended to remain in the open air, and are mounted on the ground or in a ship. In these tanks the light liquid is also supported by the water and for this purpose the tank proper is immersed in an outer container containing water and forming an integral part with the assembly.

One of the objects of the invention is to obtain a tank which is easily displaceable by simple lifting and transport. When once in position at the bottom of the water the tank according to the invention becomes invisible and inaccessible to persons not provided with special tools and equipment. It is constructed outside the water on the bank and is subsequently transported as a whole to the point on the water where it must be immersed. It must be constructed so that it rests by its base on the bottom without being secured to remain there so that it is held in position only by ballast or a mooring line and is removable even after it has been placed in position, or it can be supported at any depth in the water for example by means of floats and can be held at any distance from the bottom by connecting means and a ballast or mooring line.

The object of the invention will be described below with reference to the attached drawings which are given merely by way of example and wherein:—

Figure 1 is a vertical cross-section through one particular embodiment of the tank according to the invention,

Figure 2 is a vertical cross-section through one modification,

Figure 3 shows a detail of said modification drawn to an enlarged scale,

Figure 4 shows a plurality of tanks arranged close to a shore,

Figure 5 shows a suspension arrangement for a mid-water cock,

Figure 6 shows another arrangement comprising a cock sunk to the bottom,

Figures 7 and 8 are vertical cross-sectional views of two additional embodiments of the tank and the means to anchor same to the bottom of the sea,

Figures 9 to 14 are vertical cross-sectional views showing other means for

[*Price* 1/-]

Price 4s 6d

Price 5s. 0d

Price 33p

securing or anchoring the tank to the bottom of the sea,

Figures 15 and 16 are vertical cross-sectional views of still other anchoring means,

Figure 17 is a plan view of Fig. 16,

Figures 18, 19, 20, 21 are fractional plan views of still other anchoring means,

Figure 22 is a cross-sectional view taken on the axis of a filtering device arranged in the water pipe leading to the tank,

Figure 23 is a cross-sectional view taken on the axis of a safety valve arranged in the pipe for the stored liquid.

Figure 1 shows a tank 1 made of thin metal sheets in the shape of a solid of revolution; the said tank is allowed to float on the water and is provided with a suitable ballast 2, whereupon it is sunk at a selected spot by filling the tank with liquid. Leading from the top of the tank is a flexible or rigid pipe 3 the free end of which is closed by a valve or cock 4 which is kept floating at or near water level. One or a plurality of orifices 5 arranged in the lower portion of the tank above the ballast provides a free and permanent direct or indirect connection from the inside of the tank to the outside thereof.

The subwater tank as described is filled by forcing liquid fuel thereinto through pipe 3, e.g. by means of a pump. Tapping is effected by opening the cock 4 and under the action of the hydrostatic pressure of the surrounding medium, as water is specifically heavier than gasoline or any other liquid fuel.

The invention will be better understood by a numerical example: a sphere having a diameter of 10 meters, made of 2 mm. thick steel sheets is anchored at a depth of 20 meters below water-level. The volume of the sphere is 524 c.m. and the weight of the casing is 5 tons. When filled with gasoline having a density of 0.730 the sphere weighs $5+382=387$ tons while displacing a volume of water weighing 524 tons. It will therefore exert a pull on its mooring equal to its lift, i.e. $524-387=137$ tons. It is in some respects a submarine captive balloon the lift of which is five hundred times larger than that of an aerostat having the same volume.

If such sphere be ballasted e.g. by means of stone blocks weighing a little more than 137 tons the sphere will sink to and rest on the bottom. In this position it may be filled successively with gasoline or water without its equilibrium being destroyed.

Obviously, the pressure at the cock 4 is equal to the water head above the surface of equal pressures x—x minus the gasoline head between said surface and the cock.

In order to avoid deformation of the bottom portion of the tank under its own weight when void of gasoline, i.e. when filled with water, which weight is increased by that of the ballast, when sinking the tank or as the tank is resting on the bottom, a suitable shape may be given to said bottom portion. For instance, in the case of a spherical tank, a segment will be cut off at its lower pole in order to provide a flat base 6 as shown in Figure 2.

The orifice or orifices 5 are preferably provided with a strainer 7 to prevent them from getting blocked by foreign materials. An inside strainer will likewise protect the inlet of pipe 3. The orifices 5 may provide communication with the surrounding water either directly (Figure 1) or indirectly through bent pipes 8 or straight pipes 8a (Figure 2) the effect of which is to transfer the water inlet leading into the tank to a higher level than that where clogging by mud or sand might occur, the hydrostatic conditions remaining unchanged.

Figure 3 is a vertical cross-sectional view showing diagrammatically the detailed arrangement of the members which connect the tank with the surrounding water. A circular horizontal plate 10 acting as a deflector is secured to the water tube 8 which projects preferably through the centre thereof and prevents the water which flows in through said tube when liquid fuel is being tapped from mixing into an emulsion therewith. Effectively, the deflector 10 imparts a horizontal direction to the water and decreases its speed of flow by providing therefor an annular outlet section 11 which is considerably larger than the section of tube 8.

Surrounding said tube which acts as a guide thereto is a ring float 12 located beneath deflector 10 and arranged to float on the water and to sink in gasoline. It is necessary to avoid the danger when filling the tank that in the attempt to utilise its capacity to its full exent gasoline might be pumped into the sea. For this purpose the lower end of each water tube 8 projects into a metal walled recess providing a sump 13 in the space occupied by the ballast 2. When filling the gasoline tank and as the gasoline-water boundary level sinks into the sump 13 the float 12 comes to rest on a perforated plate 14 secured at its periphery to the sump walls and at its central portion to the tube 8. The float thus closes the orifices in said plate 14 and cuts the connection with the surrounding medium. Obviously, in order to avoid water-hammering and dangerous increases in pressure with-

in the tank, a suitable device such as one comprising an air cushion and a safety-valve may be interposed either between the pump and cock 4 or between the cock and the submarine tank.

Where said tank is immersed in a lake upstream to a dam or in the sea close to the shore it is possible to arrange the line 3 serving for handling the gasoline so that it leads to the land. In that case a pipe-line 3*a* (Fig. 4) will be connected on one hand to the top point of the tank and on the other hand to the land station 15. A simple buoy 16 may indicate the location of the tank. If in the contrary the tank is immersed without any connection to the shore, handling may be done through a flexible line 3 the upper end of which is secured to a buoy 17 carrying the cock 4.

In the case of tanks of this system located at points which are not guarded by the army and in order that the cock may not be opened wilfully, the buoy 17 (Fig. 5) is sunk in mid-water by decreasing its buoyancy slightly below zero and is suspended from an ordinary buoy 18 provided with a hoisting ring 19. In this way only a boat equipped with sufficiently powerful hoisting means will be able to lift the buoy 18 to a height of some meters above water-level to cause buoy 17 to emerge.

It is also possible to allow the cock 4, which is surrounded by a protecting network 20 (Fig. 6), to rest on the bottom of the sea and, for handling purposes to weigh it up again by means of the boat equipment with the aid of a chain or rope 21 having its upper end secured to a buoy 22. Such an arrangement ensures the advantage of a perfect fluid-tight seal for the cock by reason of the counter-pressure exerted by the water thereon.

A water thickness of some meters provides perfect protection against shelling by land or naval guns. As regards aircraft bombing, those bombs only are dangerous which are provided with time-fuses. Their effect however can be annulled by a horizontal metal net supported by submarine buoys. It will be evident however that the best protection for such submarine stores resides in the uncertainty of the enemy as to their location and also in their invisibility.

If it is desired to remove the submarine hydrostatic tank it is not necessary to resort to slow and costly diver work. The tank being still not completely filled with gasoline, i.e. containing also a certain amount of water, a small quantity of compressed air is forced thereinto which is sufficient to create a decrease of its apparent weight by an amount equal to or larger than the excess of apparent weight by which the tank is retained at the bottom of the water. The tank buoyed up in this manner will rise, the compressed air will expand and force back to the sea a corresponding amount of the water present in the tank. The apparent pressure inside will remain constant provided the total sectional area of the water tubes is sufficiently large so that no substantial head losses are caused during the expulsion of such water. The tank thereafter may be towed to and sunk at the new anchoring place chosen.

The determination of the amount of gasoline present in the submarine tank is made possible by the fact that the pressure in the gasoline pipe at a given level, e.g. at sea-level, is a function of the height of the plane of equal pressures in the tank and of the difference in the specific gravities of gasoline and sea water. If a pressure gauge be connected at that level to the gasoline pipe, the reading of the pressure will indicate the height of the level of equal pressures, i.e. of the gasoline-water boundary plane. The amount of gasoline may then be derived therefrom by computation or graphically while taking into account the shape of the tank, viz.: a sphere, a horizontal cylinder with hemispherical ends, etc.

According to Figs. 7 and 8 the tank 1 of spherical or like shape is not ballasted directly but is weighed down by external means consisting for example of iron pigs 24 secured to the tank by chains 25 or like flexible ties.

In that case, when the tank is full of a liquid specifically lighter than water or of compressed gasses, its buoyancy keeps it at a certain height above the bottom of the sea which is defined by the length of the ties 25. As the lighter liquid is replaced by water the apparent weight of the tank increases progressively and brings the tank smoothly down to the bottom.

The vertical section of the tank may then be circular without disadvantage, instead of comprising a stiffened flat bottom as hereinabove mentioned.

Moreover, in order to avoid contact of the tank with the bottom of the sea, a certain positive buoyancy may be given to the tank even when full of water, either by providing one or several fluid-tight pockets thereon or therein which are filled with air or another gas or by anchoring buoys 26 (Fig. 8) to the tank, which buoys will float or remain in a mid-water position the lift of said buoys being suitably chosen. Such mid-water buoys may be made to support a net 27 arranged

horizontally and serving to protect the tank against air-bombing.

The iron pigs 24 may be kept apart by a greater distance than that resulting from gravity alone, e.g. by means of rigid elements 28 (Fig. 7) arranged between said iron pigs or between the ties 25.

Said transverse elements 28 moreover may serve to secure a frame or board 29 made of wood or like flexible or soft material and intended to become interposed between the sea bottom and the tank in the case when the tank is to sink completely when full of water.

The iron pigs 24 or like means may be unhooked or untied when necessary and left at the bottom, e.g. when the tank is to be removed elsewhere.

The shape of the tank is not necessarily a spherical one as shown in the preceding figures.

Figure 9 shows diagrammatically in vertical cross-sectional view a hydrostatic tank 1 having a horizontally elongated shape or that of a solid of revolution about a vertical axis of symmetry and the lower sides of which are provided with an outer horizontal flange 30 having a sufficient area to receive the load 31 necessary to retain the tank at the bottom of the sea. In that case the load may be sand or gravel or stones transported to the bottom from sea-level by a dredge or a crane.

Figure 10 shows diagrammatically in vertical cross-sectional view a cylindrical hydrostatic tank with a horizontal axis; the tank is sheathed with a concentrical wall 32 and the space therebetween is filled with concrete acting as ballast.

Figure 11 shows diagrammatically in vertical cross-sectional view a cylindrical hydrostatic tank with a horizontal axis, which tank is rigid with a bottomless metal container 34. The cavity of said container below the tank, after said tank has been sent to the bottom, is filled from water-level with sand or gravel 35 through the space between the body of the tank and the vertical wall of the container; concrete is poured thereafter to provide a cover 37 on said ballast, which cover adheres to the tank and the wall of the container 34.

Figure 12 is a diagrammatical vertical cross-sectional view showing a hydrostatic tank secured to one or several concrete blocks 38, previously sunk in the sea and providing an anchorage, by means of chains or mooring ties 39. Said ties have one end thereof rigid with the tank and are run about guides 40 sealed in the concrete while their other ends are arranged to be secured to the top of the tank by means of adjusting members 41. Such modification allows the tank to be anchored conveniently by a pull exerted from the surface on the ties 39, the tank being partly full of liquid in order that it may retain a certain amount of buoyancy. Moreover, the said ties are more easily secured at the top portion of the tank as the divers will work at smaller depth.

Figure 13 shows diagrammatically in vertical cross-sectional view a modification wherein a pair of cylindrical horizontal hydrostatic tanks are coupled by cross-beams 42 providing a platform on which, after the tanks are sunk, a ballast can be heaped in the form of sand, gravel or stones 43. The connection between the tanks and cross-beams may be articulated. The tanks are of suitable construction to resist the pressure of the ballast and the lateral thrust of the same which tends to push them apart.

Figure 14 shows diagrammatically in vertical section another modification in the arrangement of a horizontal hydrostatic tank having an elliptical section but which may also have a section of circular or other shape. This tank is placed at the bottom of a channel 44 hollowed out by means of a dredge for example in the sand bed of a river. The body of the tank is provided laterally with ropes or chains 45 to which transverse anchoring hooks or bars are secured which may be constituted for example by profiled iron bars 46. When the tank is in position the channel is filled with sand 47 by the dredge.

The tank is thus in safe-keeping and need be raised only when it is to be filled with a liquid lighter than water. Moreover, the protection against bombing is increased by the layer of sand which covers the tank. The admission and discharge of water may be ensured by the same means as in the case of Fig. 2. For this purpose a tube 48 leads from the top of tank 1 to a small distance above the bottom of said tank. It is prolonged externally by a tube 48*a* which issues above the layer of sand 47 and the upper end of which is covered with a rose 48*b* through which the surrounding water can pass to and from the reservoir 1. Another pipe 49 is connected to the upper part of the tank 1 and leads to a float valve 49*a* which is maintained above the level of the water and serves for the introduction and removal of the liquid lighter than water in the tank 1.

In Figs. 9 to 13 the connecting means between the tank and the surrounding medium and the water level which are necessary for handling the liquid fuel and such as are described with reference to

Figs. 1 to 8 are omitted for the sake of clarity.

In order to obtain a strong and economical mooring in the case of large capacity tanks developing a considerable lifting force (e.g. several hundreds of tons) it is advantageous to employ the following method:

The principle consists in securing the mooring tie or ties to a board sole which is sunk to the bottom of the sea or the like and which thereafter is covered with a sufficient amount of loose material such as sand, gravel or stones so as to hold the sole perfectly steady in spite of the stresses set upon the mooring ties.

Said sole may be solid or latticed; in some cases it will be stiff but generally it is advantageous to make up the sole of flexible or hinged members providing for example a network in order that it may conform to the more or less uneven surface of the bottom irrespective of its dimensions.

The loose load may be sand or gravel or stones and will be transported from water-level by means of a crane or a dredge. The dimensions of the sole or base system as well as the amount of load and the number and section of the mooring lines, chains, tie-rods or ropes will naturally depend on the lifting force that is to be set up by the moored structure.

The principle of the method is illustrated diagrammatically in Fig. 15. This is a vertical cross-sectional view showing the sea bottom at 51, the base system at 52, comprising rigid members 53 hinged to one another by suitable links 54, the mooring ties at 55, the load transported from water-level at 56.

The base sole may be constructed in every possible manner. In its simplest embodiment it will consist of a rigid board 52*a*, either a flat block of reinforced concrete or a metal plate stiffened by means of sectional iron bars providing ribs, the mooring chain 55 being secured either at the centre or at several points at the edges thereof. Fig. 16 is a vertical cross-sectional view corresponding to the plane view shown in Fig. 17.

Such a single element being insufficient where the resisting force must be high or where the sea-bottom is uneven, the base system will be arranged as described in such manner that it may deform and more or less conform to the shape of the bottom while displaying a sufficient horizontal area. The base system consequently may be provided generally in any desired manner by the combination of rigid or flexible plates, ropes, chains, bars, links or concrete blocks.

Figure 18 is a plan view showing the system as made up of rigid sectional steel bars 63 secured to one another by means of hinge rings 64.

Figure 19 is a plan view showing a base system made up of square reinforced concrete plates 65 hinged to one another by rings 66.

Figure 20 shows a base system made up of chains 67.

Figure 21 is a diagrammatical plane view showing a system made up of rigid grid-like elements 68 made of sectional iron and hinged to one another by means of chains 69.

Figure 22 is a vertical cross-sectional view showing an attachment which may suitably be used for example where the hydrostatic tank is anchored upstream to a water dam. In this case, considering that the water at certain times in the year is loaded with mud or sand and that it renews continuously about the tank, it is advantageous to avoid the accumulation of such deposits in the tank whenever the liquid fuel is replaced by water. With this object in view, the pipe 70 connecting the bottom of the tank to the surrounding medium is provided at its outer end with a strainer comprising a pair of perforated walls of sufficient area and having a roof 73 arranged thereabove which is intended to retain the solid particles which tend to sink, a suitable filtering material, e.g. a coarse fabric 74, being maintained between the perforated walls 71, 72 to trap the sand and mud as the water flows into the tank. Such fabric will be cleaned automatically when the water flows out of the tank again as a result of liquid fuel being forced into the same. A separate pipe may connect the pumping set to the inside of the above described device and serve to inject water under a higher pressure in order to clean the filter without setting abnormal pressures upon the tank.

Figure 23 is a diagrammatical cross-sectional view showing a safety valve mounted on the hydrostatic tank as an intermediate means between the latter and the liquid fuel pipe-line. The purpose of said fitting is automatically to stop the fuel feed to the tank when same is about to be full; this avoids an excess in the feed whereby fuel would be forced to the outside. It consists of a float 75 suitably balanced by a counterweight 76 and provided with a cam 77 operating a valve 78 and rigid with a beam 79 adapted to swing about a fixed pin 80 and to which the float and the counterweight are hung by rods 81 and 82. The feature of said device is that the apparent density of the float is between that of water and the liquid fuel, e.g. 0.850 for a gasoline

having a density of 0.720, and also that the valve dips only in the hydrocarbon and consequently cannot be fouled by corrosion due to soft or salt-water or by aquatic plant or snail deposits.

The advantages of the tank according to this invention, particularly as far as war stores are concerned, are as follows:—

All danger of evaporation, explosion or fire is suppressed by the fact that a surface of evaporation is no longer present.

Spying and its consequences are made difficult on account of the brevity of the launching, ballasting, towing and sinking operations as well as the possibility in war time of rapidly altering the geographical location of the subwater stores.

The protection against bombing as compared to that of underground stores is of the same order or even better because the target to be bombed is invisible and its position is unknown or uncertain and can be altered.

The entirely hydraulic character of the liquid fuel handling as far as tapping is concerned makes such handling much simpler as it necessitates no ventilation, no lighting, no staff attached to the store and no local power and pumping plants.

The cost of the tanks according to this invention is much lower than that of underground or even surface tanks of equal capacity.

Finally, the construction and putting into operation of a storage plant made up of tanks according to this invention can be carried out in a comparatively short time, e.g. within a few weeks, whereas the construction of the present underground stores takes numerous months.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Tank for the sub-water storage of liquids lighter than water characterised by the feature that it comprises a container held by a ballast, mooring line or other suitable means at the bottom or at any level of the water, said container comprising means for the admission or discharge of the surrounding water to or from its lower part and at its upper part means for the admission or discharge of the liquid lighter than water.

2. A tank as claimed in Claim 1 wherein the casing adapted to contain said lighter liquid is made in the shape of a solid of revolution.

3. A tank as claimed in Claim 1 wherein means are provided to keep the casing immersed and comprise a heavy mass located at the bottom of said casing, said mass being sufficient to overcome the hydrostatic lifting force even when the casing is full of said lighter liquid.

4. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a heavy mass attached to the bottom of said casing, said mass being sufficient to overcome the hydrostatic lifting force even when the casing is full of said lighter liquid.

5. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a heavy mass and flexible ties connecting said mass to the casing, buoys and flexible ties connecting said buoys to the casing and a protecting net sustained by said buoys above the casing.

6. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise heavy blocks, flexible ties connecting said blocks to the casing, rigid members adapted to keep said blocks apart from one another and a board of soft material secured to said members and adapted to prevent the underside of the tank from contacting the water bottom.

7. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a mass of sand or the like resting on the casing and the water bottom.

8. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a broad sole secured to said casing outside of the same and sand or like material resting on said sole.

9. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a caisson open both at the top and the bottom thereof and secured about the lower portion of the casing, sand or like material filling said caisson when same is resting on the water bottom and a concrete cover resting on said sand.

10. A tank as claimed in Claim 1 wherein the means adapted to keep the casing immersed comprise a broad flexible sole adapted to conform to the shape of the water bottom, ties connecting said casing to said sole and sand or like material covering said sole.

11. A tank as claimed in Claim 1 comprising a buoy secured to the free end of the flexible pipe line for feeding the lighter liquid in and out and adapted to sustain said end at a certain depth in the water.

12. A tank as claimed in Claim 1 comprising a water inlet and outlet pipe one end of which opens at the outside of the casing while the other end opens close to the bottom of the same.

13. A tank as claimed in Claim 1 comprising a horizontal partition providing a

small chamber at the bottom of the casing, a water inlet and outlet pipe opening at its upper end outside of the casing and at its lower end within said chamber, an aperture in said partition, a deflector plate above said partition and a valve floating between said partition and said deflector plate, said valve being adapted to rise in the water and to sink in the lighter liquid, when it will close the aperture in said partition.

14. A tank as claimed in Claim 1 comprising means automatically to close the lighter liquid pipe a little before the casing is completely filled with said liquid, such means comprising a valve adapted to control the aperture of said pipe at the top of the casing and a balanced float adapted to rise in the water and to sink in the lighter liquid and to close said valve when the boundary surface between the liquids sinks to a predetermined level.

15. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 1.

16. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Figs. 2 and 3.

17. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 4.

18. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 5.

19. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 6.

20. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Figs. 7 and 8.

21. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Figs. 9 to 14.

22. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Figs. 15, 16 and 17.

23. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Figs. 18, 19, 20 and 21.

24. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 22.

25. A tank intended for the subwater storage of a specifically lighter liquid substantially as described and shown in Fig. 23.

Dated this 23rd day of May, 1936.

MARKS & CLERK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

Fig. 1

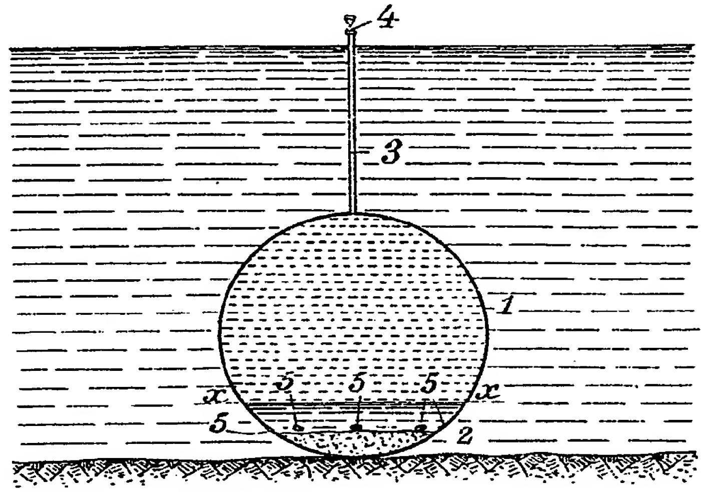


Fig. 2

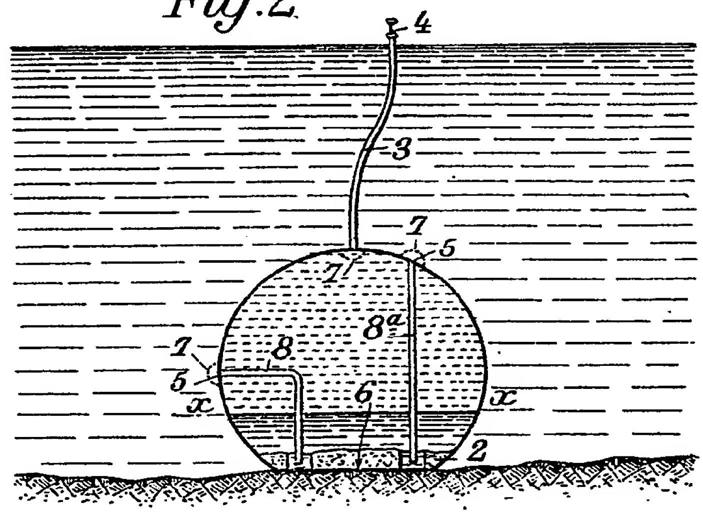
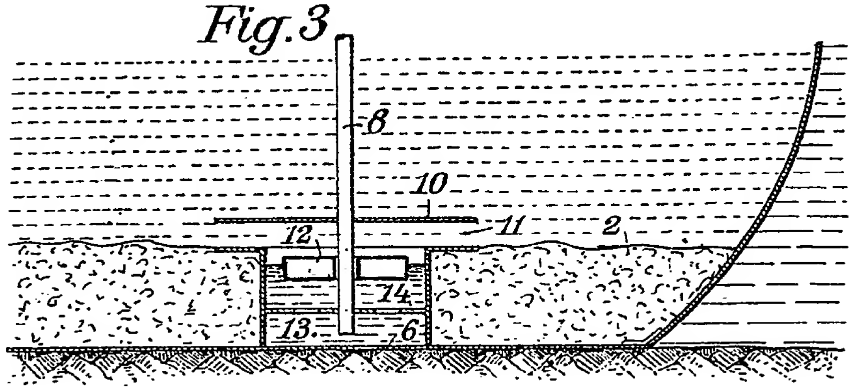


Fig. 3



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SHEET 1

Fig. 4

Fig. 5

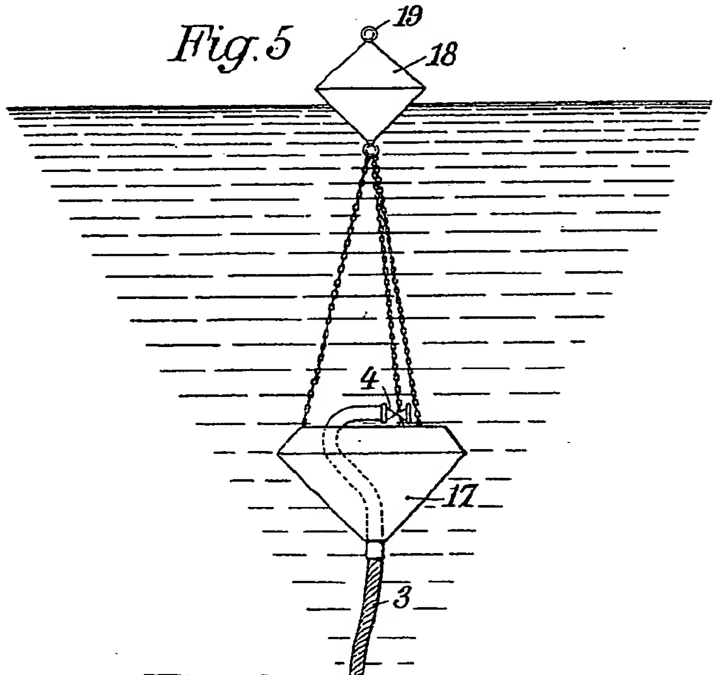

Fig. 6

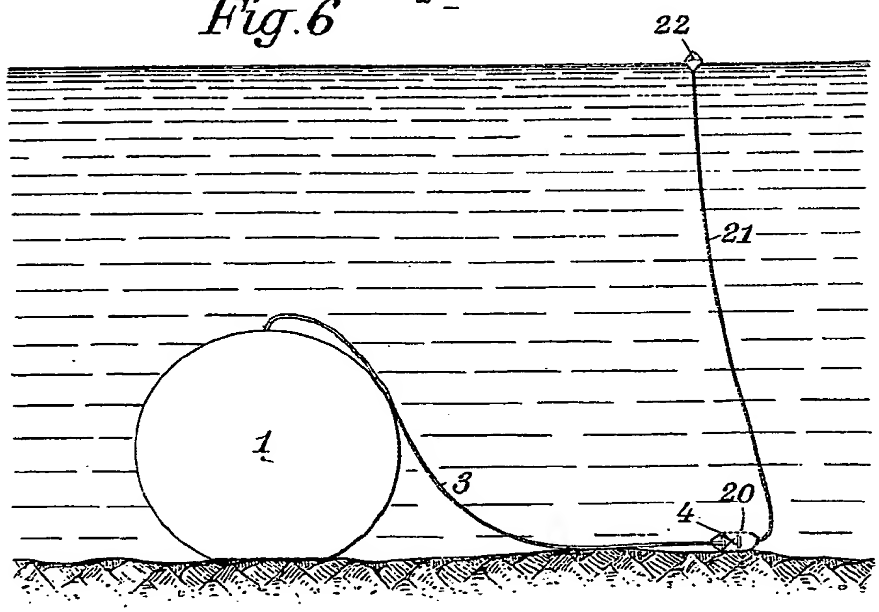

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Fig. 1

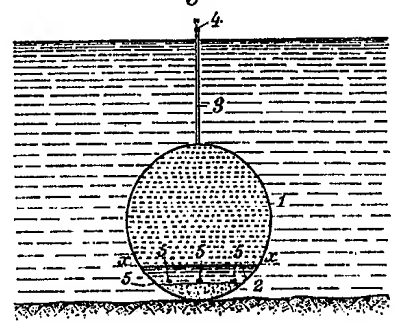

Fig. 2

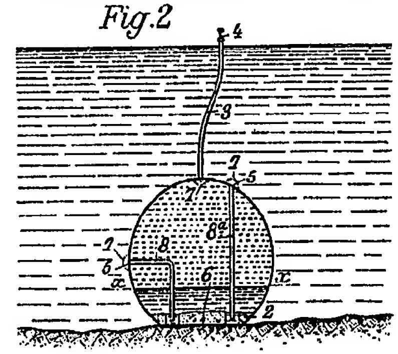

Fig. 3

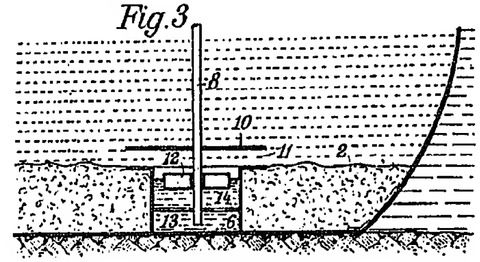

Fig. 4

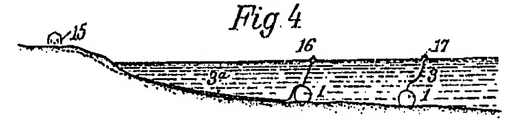

Fig. 5

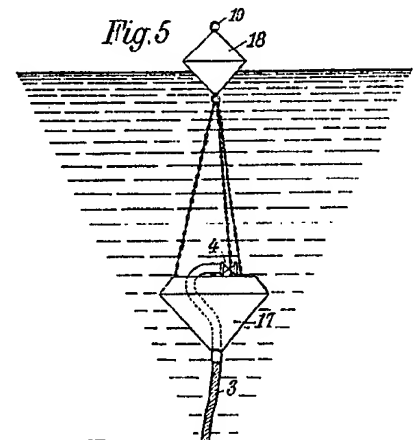

Fig. 6

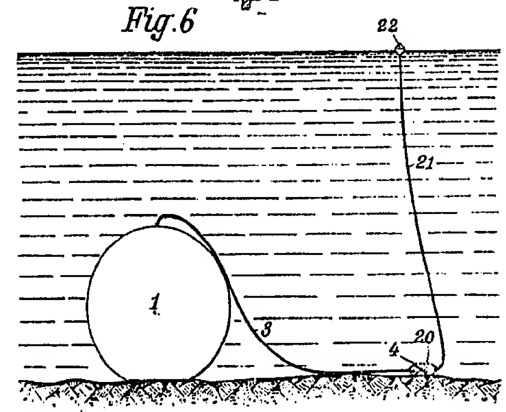

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Fig. 7

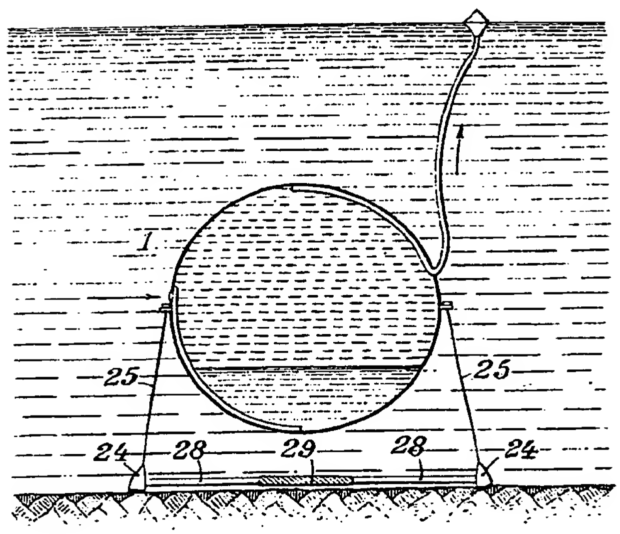

Fig. 8

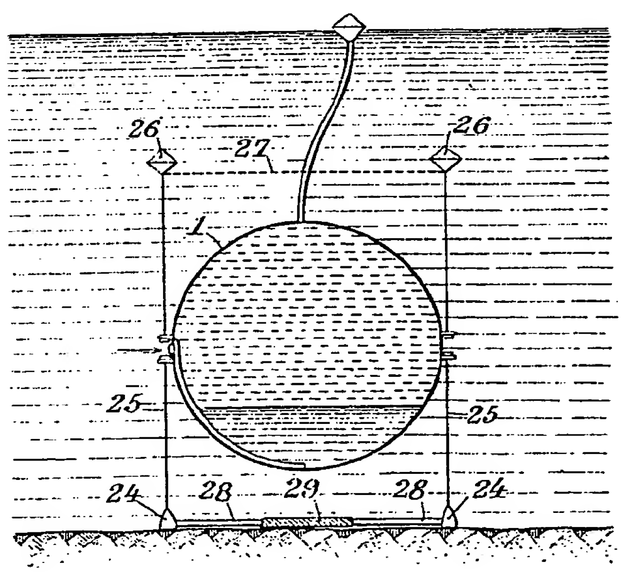

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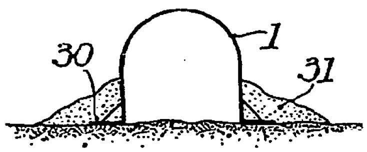
Fig. 9.



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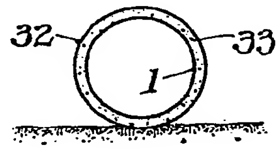

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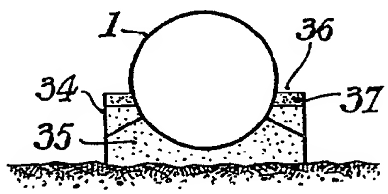

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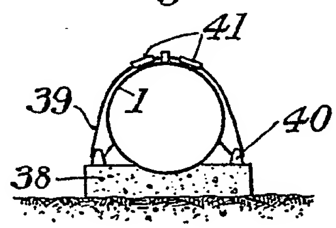

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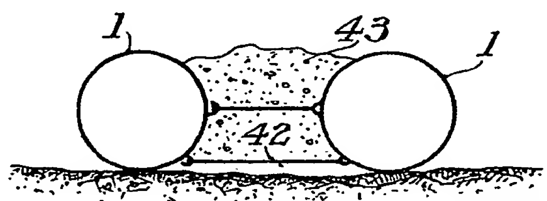

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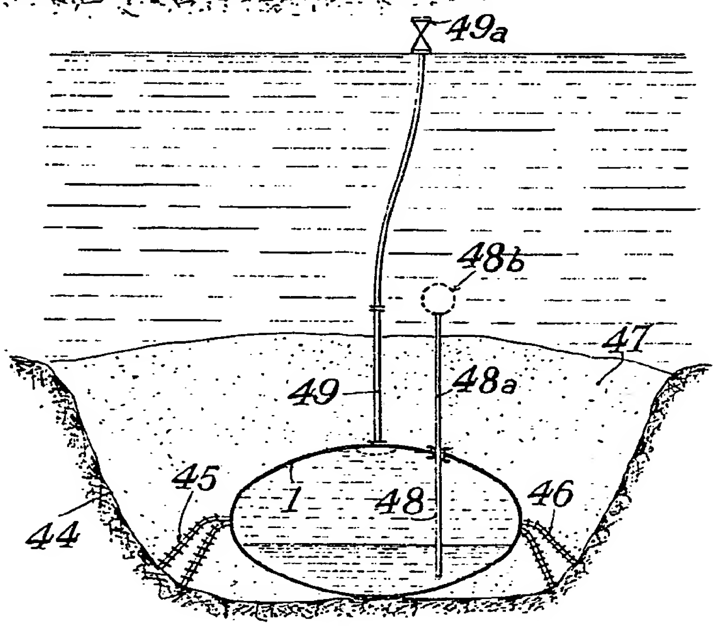

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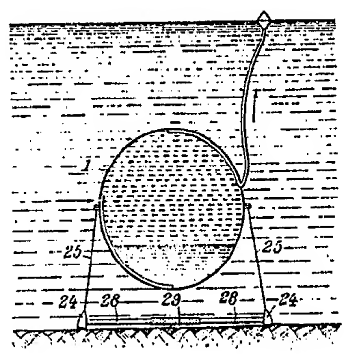

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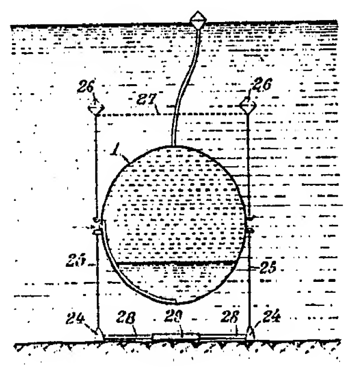

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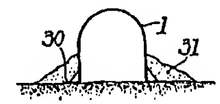

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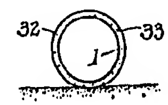

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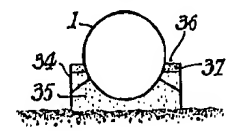

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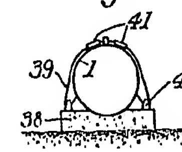

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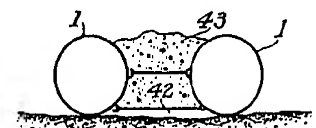

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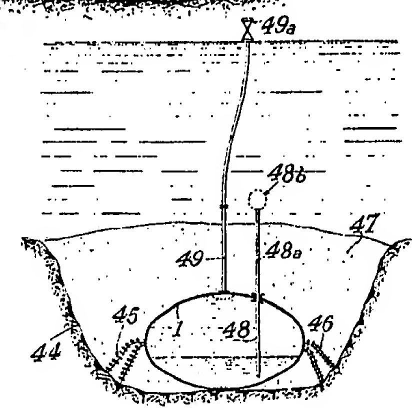

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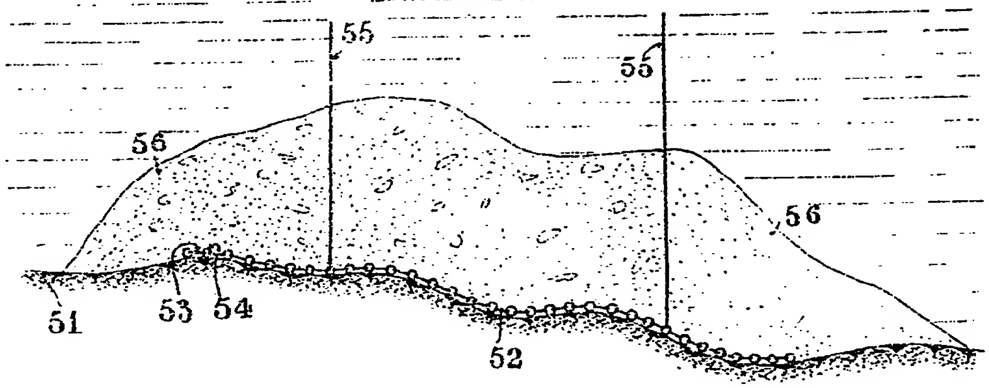

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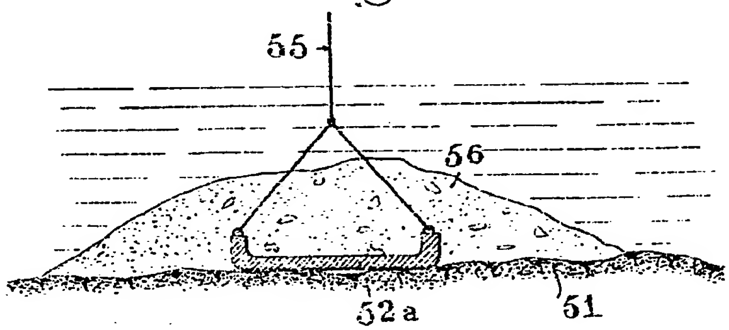

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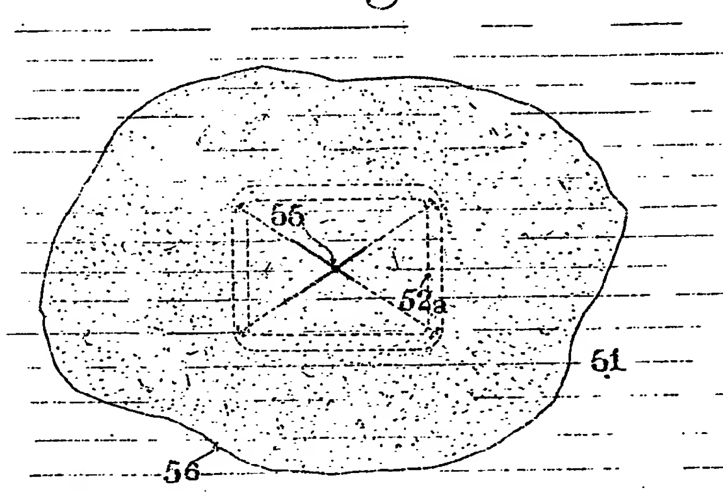

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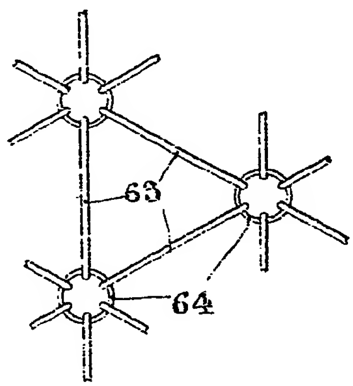

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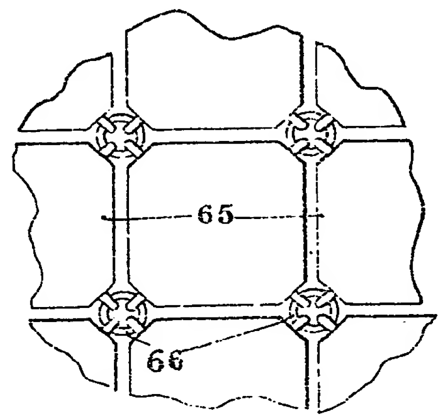

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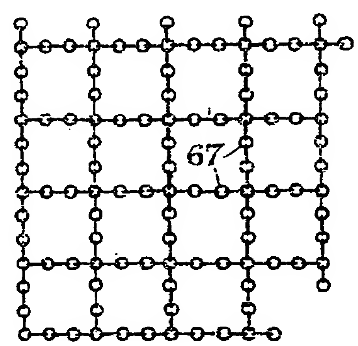

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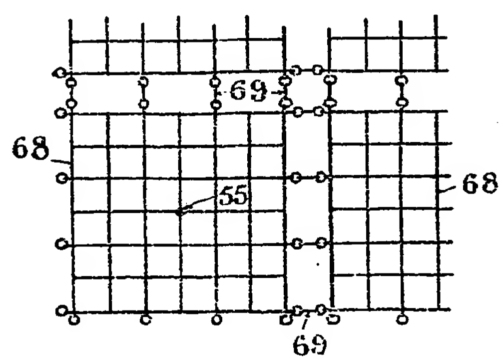

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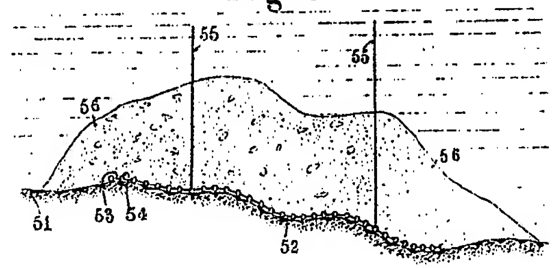
Fig. 15.



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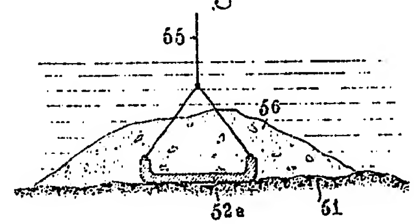

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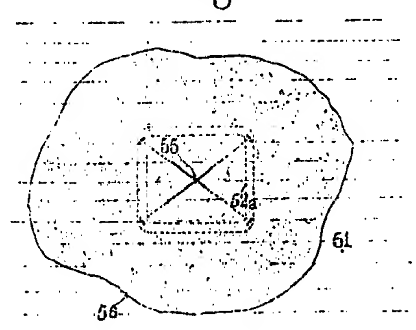

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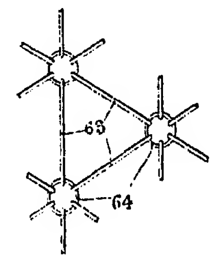

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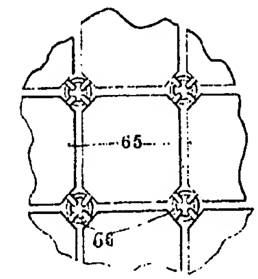

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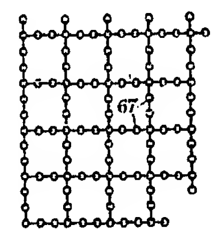

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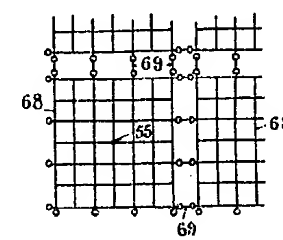

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Fig. 22

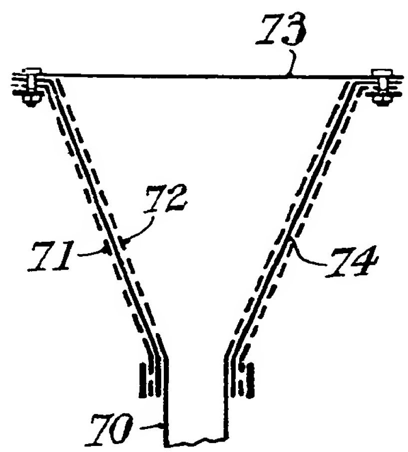

Fig. 23